# Stabilization of FGD by-product using fly ash

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## 1. Introduction

In 2006, FGD scrubber systems at coal-fired power plants generated approximately 27.4 million metric tons (30.2 million tons) of material, or 24.2 percent of all coal combustion products.(1) Due to an expected increase in scrubbing applications, the amount of FGD produced is expected to grow during the next few decades.(2)

Approximately 30 percent of the FGD material produced in 2006 was beneficially used.(1) Fixated or stabilized calcium sulfite FGD scrubber material has been used as an embankment and road base material. FGD products have also been used in place of gypsum, as feed material for the production of Portland cement. In addition, FGD material has been used in flowable fill in mine reclamation and in aerated concrete blocks. Oxidized FGD scrubber material (calcium sulfate high in gypsum content) is used in the manufacturing of wallboard.(3) For use as wallboard gypsum, oxidized FGD scrubber material only requires drying to a specified solids content and does not require fixation or stabilization. Wallboard production represents the largest single market for FGD scrubber material.(1)

Use of FGD material has increased over the past decade because FGD material is being used as a source of gypsum for wallboard and Portland cement production. There was a 5 percent increase in the utilization of FGD material between 2005 and 2006, representing an additional 453,000 metric tons (500,000 tons) of material.(1)

Fixated or stabilized flue gas desulfurization (FGD) scrubber material can be used as a stabilized base or subbase material in the same manner as lime-fly ash or cement-stabilized base materials. Fixated FGD scrubber material may be used in an "as produced" condition, provided the material meets specifications, or the FGD scrubber material can be modified with additional reagents such as Portland cement, lime, fly ash, etc. to improve characteristics. In addition to adding fixation reagents, an aggregate material (sometimes coal bottom ash) can be blended with the fixated FGD scrubber material to improve material performance. Properly designed fixated FGD scrubber material has comparable strength development and durability characteristics to that of conventional stabilized base materials.

# 2. Materials and Experimental Methods

## *2.1. Raw material*

FGD and filter cake used in this investigation were provided by the P4 power plant, We energy. Class C fly ash obtained from colombia power plant. The natural water content of FGD and fliter cake are 34% and 107.5%, respectively. Table 1 and Table 2 show the chemical and mineralogical composition of FGD and filter cake. Table 3 presents the chemical properties of fly ash. Optical micrograph of FGD and filter cake were described by Table 1.

Table 1 Chemical copposition of FGD and filter cake

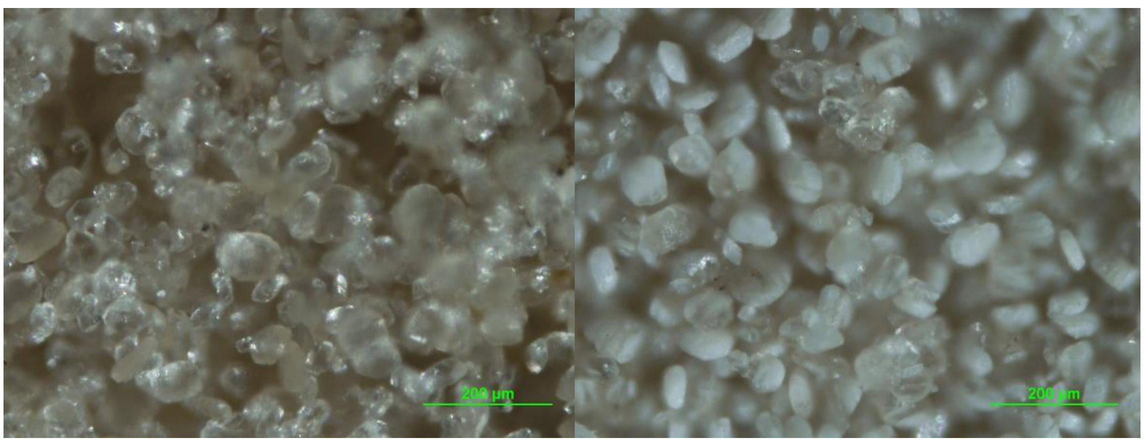
| SAMPLE | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | CaO | MgO | $Na_2O$ | $K_2O$ | LOI | Total |
|---|---|---|---|---|---|---|---|---|---|
| FGD | 0.81 | 0.05 | 0.17 | 38.74 | 0.26 | 0.06 | 0.02 | 7.74 | 47.88 |
| filter Cake | 16.66 | 4.43 | 7.33 | 13.01 | 11.54 | 0.6 | 1.37 | 29.8 | 86.28 |

Table 2 Mineralogical composition of FGD and filter cake

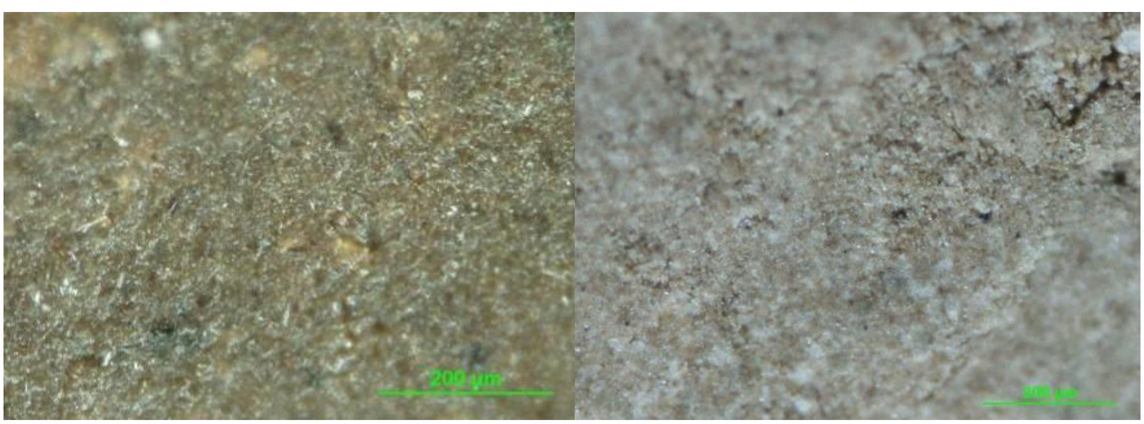
| | Dihydrate Gypsum | Quartz | Smectite | Calcite | Feldspar /Illite / Mica | Amorphous |
|---|---|---|---|---|---|---|
| FGD | 93 | 0 | 6 | 1 | 0 | 0 |
| Filter Cake | 60 | 7 | 1 | 2 | 5 | 25 |

Table 3 Chemical composition of fly ash

| SAMPLE | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | CaO | MgO | LOI | Total |
|---|---|---|---|---|---|---|---|
| filter cake | 31.1 | 18.3 | 6.1 | 23.3 | 3.7 | 0.7 | 47.88 |




natural FGD powder    oven dried FGD powder




natural filter cake    oven dried filter cake

Fig. 1 Optical microgragh of FGD and filter cake

## *2.2. Experimental Methods*

### 2.2.1. Compaction test

To determine strength development in FGD-fly ash admixtures and FGD alone, the optimum moisture content and maximum dry dencity were conducted based on ASTM D 698.

### 2.2.2. California Bearing Ratio (CBR) test

CBR test was preformed on pure FGD and filter cake in accordance with D 1883.

### 2.2.3. Unconfined Compressive Strength Test

Unconfined compression (UC) tests were conducted on compacted FGD-fly ash mixtures as well as the FGD alone using Harvard compaction equipment following the procedure in ASTM D4609. The Harvard mold is 33 mm in diameter and 72 mm in height. Testing showed that 3 layers with 25 tamps/layer were adequate to achieve approximately the same dry unit weight as obtained with the standard Proctor effort. After compaction the specimens were extruded, sealed in plastic, and stored in 100 humidity for 7 days curing. After that, the specimen were tested in unconfined compression at a strain rate of 0.15 mm/min.

# 3. Results and Discussion

### *3.1.1. Results of Compaction Test*

Fig.2 shows that the dry unit weight is increasing with an increase of fly ash content. The peak of each curve is tending to move to a lower moisture content. It indicated that adding more fly ash can improve the dry unit weight of FGD-fly ash adminstures.

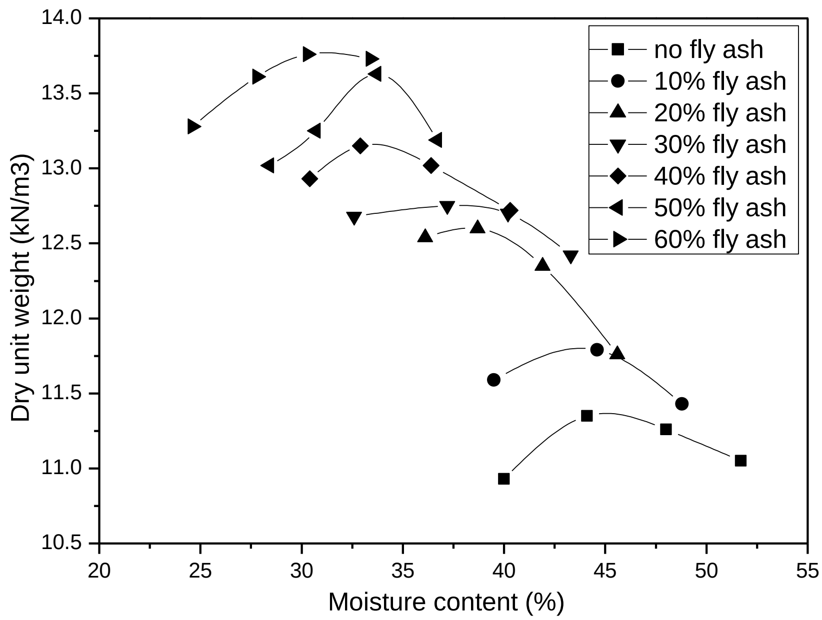



Fig.2 Compaction curves for FGD with varying fly ash content

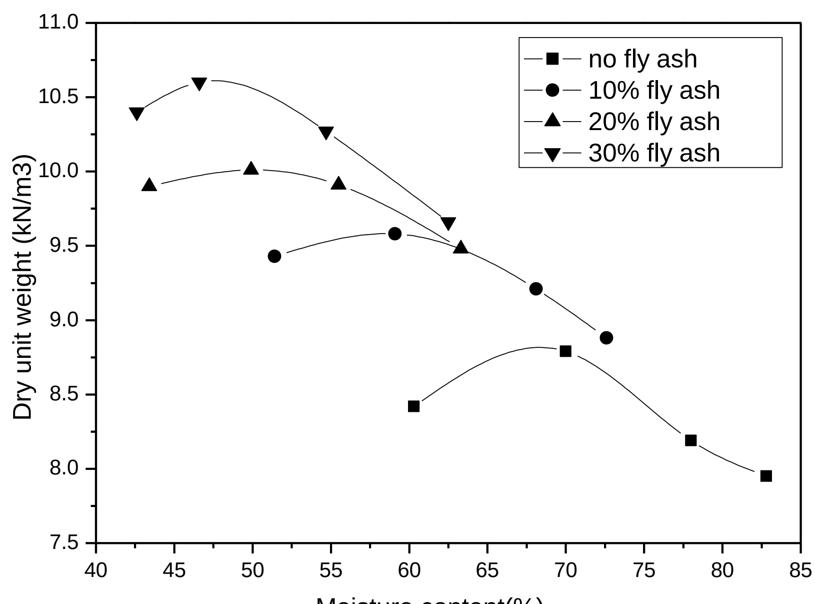



Fig.3 Compaction curves for filter cake with varying fly ash content

Fig.3 shows that the dry unit weight of filter cake is also increasing with an increase of fly ash content. The peak of each curve is shifting to the lower moisture content. It indicated that adding more fly ash can improve the dry unit weight of fly cake-fly ash adminstures.

*3.2. Results of California Bearing Ratio (CBR)*

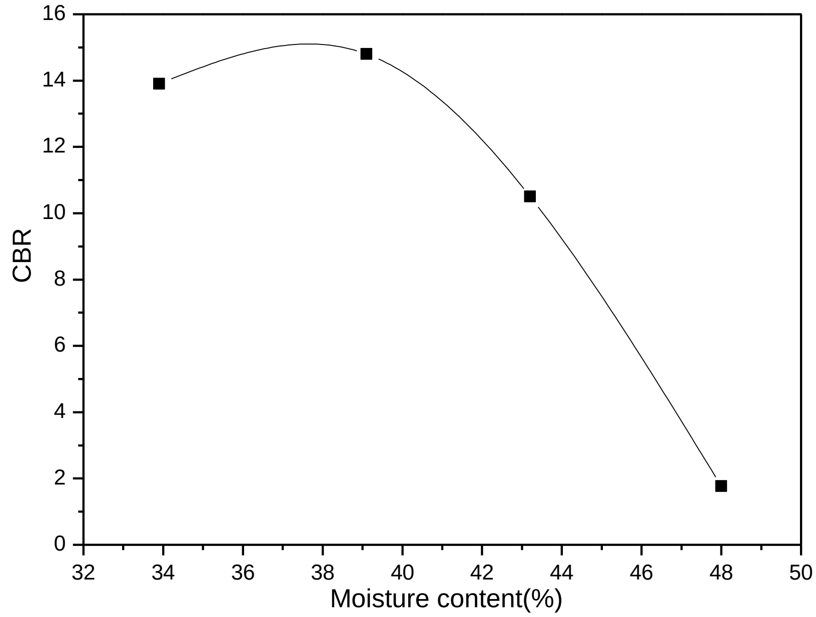



Fig. 4 CBR results for FGD at different moisture content

CBR results for FGD at different moisture content is shown in Fig. 4. The maximum of CBR value reaches 15 while the specimens prepared around 39 precent moisture content.

The CBR value of is FGD at 40 percent water content is about 20.7 after mixing with 10 percent fly ash and curing for 7 days.

Fig. 5 shows CBR values for filter cake at different moisture content. The natural moisture content of filter cake is about 107.5 precent. It indicates that CBR value is increasing with an decrease of moisture content and the optimum water content is ranging from 40 to 60 percent.

The CBR value of filter cake at 107.5 percent water content is about 3.7 after mixing with 10 percent fly ash and curing for 7 days.

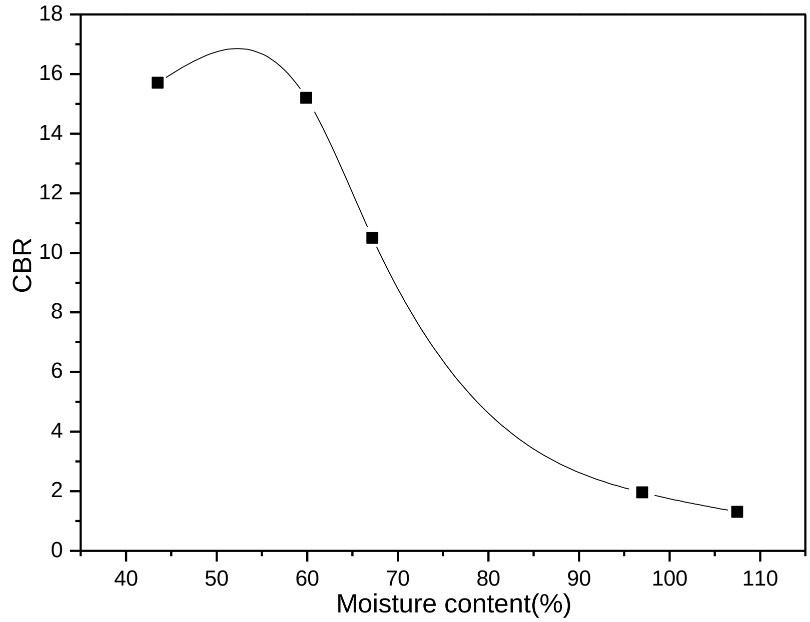



Fig. 5 CBR results for filter cake at different moisture content

### *3.3. Results of Unconfined Compressive Strength Test*

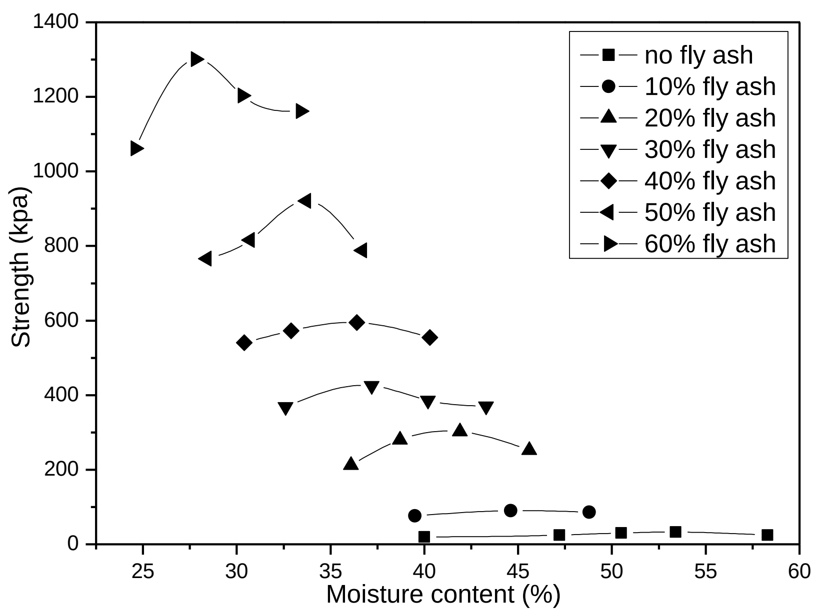



Fig 6. UC strength curves for FGD with varying fly ash content

UC strength curves for FGD with varying fly ash content are given in Fig. 6. The UCS increases fast with an increase of fly ash content and reaches 1.3 Mpa while adding 60 percent fly ash in the mixture at 27.5 precent moisture content. It indicates that

Columbia's class C fly ash is a cementitious material which can reduce the water requirement in the mixtures

UC strength curves for filter cake with varying fly ash content are shown in Fig. 7. The maximum value of UCS curve (30% fly ash) is twice as much as that without fly ash.

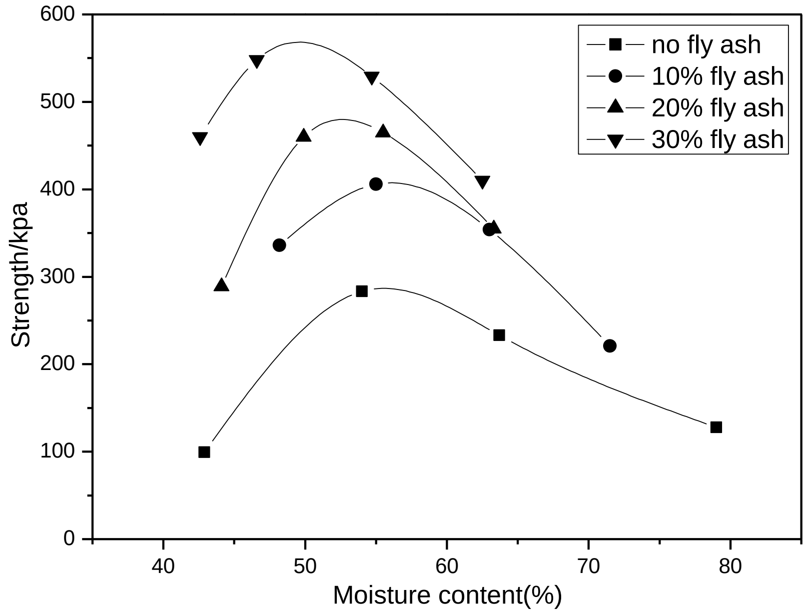



Fig 7. UC strength curves for filter cake with varying fly ash content

## 4. Conclusins

(1) Fly ash have a obvious effect on the dry unit weight of FGD and filter cake. They are increasing gradually with the increase of fly ash content and reaching 13.8 $kN/m^3$ and 10.7 $kN/m^3$, respectively,

(2) CBR values also increased with a 10 percent fly ash content.

(3) Unconfined compression strength of FGD and filter cake is increasing sharply with the increase of fly ash content. The maximum of UCS of FGD mixed with 60 percent fly ash reaches 1.3 Mpa. The maximum of UCS of filter cake mixed with 30 percent fly ash is slightly greater than 0.55 Mpa.

# Reference

1. American Coal Ash Association (ACAA). 2006 coal combustion product (CCP) production and use. American Coal Ash Association; Aurora, CO, 2007.

2. Bigham JM, Kost DA, Stehouwer RC, Beeghly JH, Fowler R, Traina SJ, Wolfe WE, Dick WA. Mineralogical and engineering characteristics of dry flue gas desulfurization products. Fuel 2005;84:1839-48.

3. Electric Power Research Institute (EPRI). Flue gas desulfurization by-products: Composition, storage, use, and health and environmental information. EPRI, Inc; Palo Alto, CA: 1999.